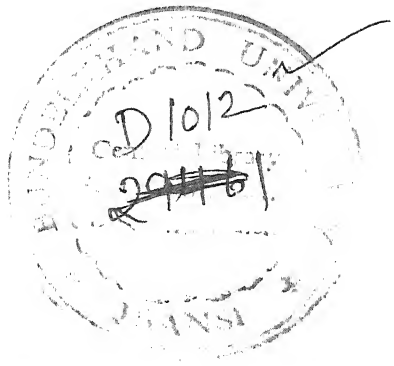
THE EVALUATION OF CREATININE CLEARANCE IN SPINAL CORD INJURY PATIENTS

THESIS

For

DOCTOR OF MEDICINE

(MEDICINE)



BUNDELKHAND UNIVERSITY
JHANSI (U. P.)

1993

MAHIPAL SINGH

CERTIFICATE

This is to certify that the work entitled "THE EVALUATION OF CREATININE CLEARANCE IN SPINAL CORD INJURY PATIENTS", which is being submitted as thesis for M.D. (Medicine) examination of Bundelkhand University, 1993 by DR. MAHIPAL SINGH, has been carried out in the department of Medicine and Orthopaedics, M.L.B. Medical College, Jhansi.

He has put in the necessary stay in the department according to the University regulations.

Dated: Sept. 30th, 1992

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C E R T I F I C A T E

This is to certify that the work entitled "THE EVALUATION OF CREATININE CLEARANCE IN SPINAL CORD INJURY PATIENTS" has been carried out by DR. MAHIPAL SINGH under direct supervision and guidance in the Department of Medicine and Orthopaedics, M.L.B. Medical College, Jhansi. The techniques, observations and calculations incorporated in this thesis have been undertaken by the candidate himself and checked by me from time to time.

Dated : Sept. 29th, 1992

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CERTIFICATE

This is to certify that the work entitled "THE EVALUATION OF CREATININE CLEARANCE IN SPINAL CORD INJURY PATIENTS" has been carried out by DR. MANIPAL SINGH under my direct supervision and guidance. The techniques and observations recorded in this thesis have been undertaken by the candidate himself and checked by me from time to time.

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ACKNOWLEDGEMENT

Here, standing in the shade of my recently built house, I can not help but feel the presence of all those, who added the bricks and cement from the foundation to the completion of this project under which I feel so secure to day. The upsurge of gratitude and love for their kind and loving co-operation in this presentation prostrate me before all those who helped me in all humility and obeisance.

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Dated: Sept.29,1992

Malkpal Singh

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C O N T E N T S

INTRODUCTION

INTRODUCTION :

Accurate determinations of creatinine clearance is imperative to avoid in appropriate doses of drugs excreted by the kidneys. Creatinine clearance may be predicted or measured by 24 hour urine collection. Spinal cord injury patients present several problems. Complete urine collection is difficult owing to neurogenic bladder in addition to the inherent difficulties of collecting a 24 hour specimen in an institutional setting. Thus reliance upon prediction methods often is increased owing to delays in actual measurement of creatinine clearance. Also aminoglycoside treatment of urinary tract infection is frequent in spinal cord injury patients. The accuracy of the prediction method must be relied upon to prevent aminoglycoside nephrotoxicity. Many of the current methods to predict creatinine clearance were derived from an analysis of the creatinine production of 474 neurologically intact hospitalized patients (Kampmann & Associates, 1974). It was seen that the validity of using these predictive equations and nomograms in spinal cord injury patients is not proper as Mohler et al (1986) found that the 24 hour urinary creatinine production in spinal cord injury

patients is less as compared to age and sex matched controls recorded by Kampmann & Associates (1974). Mohler et al proposed two simple equations and nomograms for more accurate prediction of creatinine clearance in spinal cord injury patients.

There are no reports available about creatinine clearance in spinal cord injury cases in Indian population.

So the present work has been designed to evaluate creatinine production and clearance in spinal cord injury cases in Bundelkhand region and compared the results with age and sex matched controls reported by Kampmann and Associates (1974).

AIMS & OBJECTIVES :

1. To evaluate the creatinine production and clearance in spinal cord injury patients.

2. To compare the results of creatinine production and clearance in spinal cord injury patients of Bundelkhand Region with age and sex matched neurologically intact hospitalized patients recorded by Kampmann & Associates.

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REVIEW OF LITERATURE

REVIEW OF LITERATURE

For the creatinine clearance a lot of work has been done in different categories of patients. Creatinine excretion has a definite relation to a fat free mass (or lean body mass). The lean body mass is considered to be directly propotional to active tissue mass. It provides total body weight for expression of such factors as metabolism, nutritional requirements and drug doses[24].

The lean body mass (Kg) is equal to 20.97 + 0.5161 (urinary creatinine excretion mg/hour). Table for easy calculation of lean body mass (LBW) from height and weight is introduced by R. Hume (1966)[30].

The relation of creatinine clearance to muscle mass has been earlier studied and summarised in monographs by Hunter, Breard, and Brody[12,2,3].

Male have a higher creatinine concentration and a greater excretion than female with same creatinine clearance, 1.73 per square meter, is probably due to male's relatively larger muscular mass[28]. Negative nitrogen and calcium balance result from immobalization alone[7] and even greater changes follow skeltal[11] and spinal cord trauma[6]. Atrophy of musculature results in persistant changes[31] in body composition.

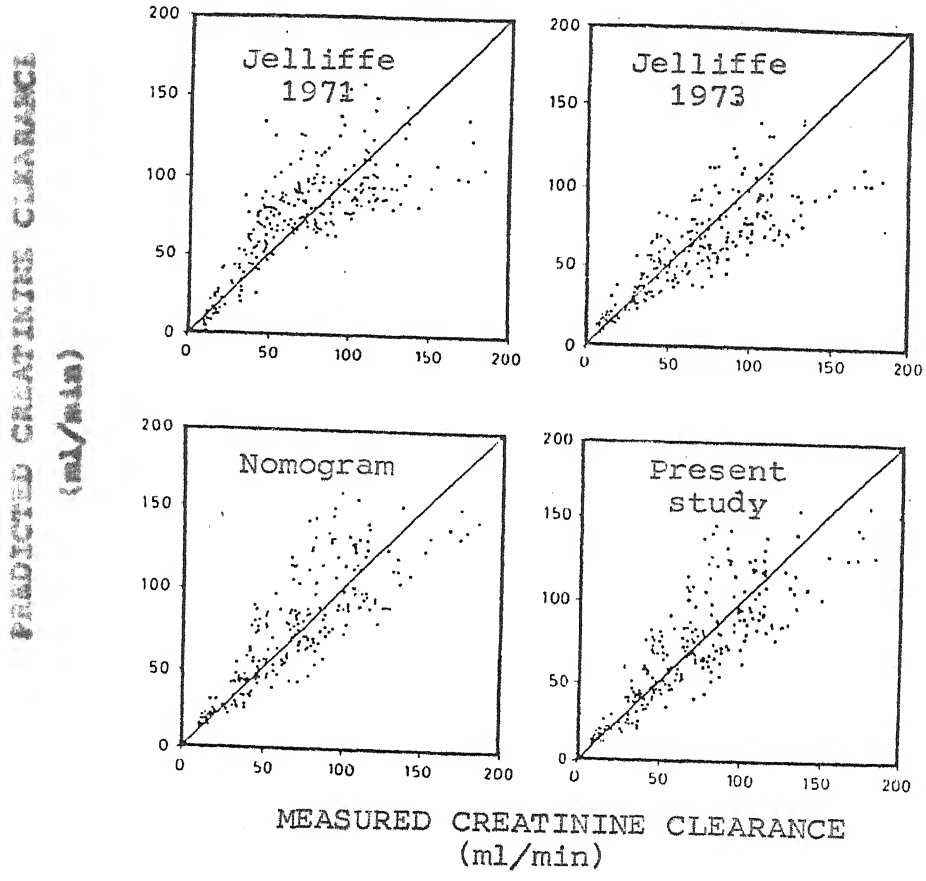
Sjoeback - Nielsen and Co-workers (1971)[32] purposed the equations and nomogram to predict creatinine clearance .

In 1976 Cockcroft and Gault[5] suggested a formula to predict creatinine clearance from serum creatinine in male.

$$\text{Creatinine Clearance} = \frac{(140 - \text{age(years)}) \times \text{weight(kg)}}{72 \times \text{serum Cr. mg\%}}$$

In female the creatinine clearance would be 15% less than male.

Predicted & measured creatinine clearance by Cockcroft and Gault



They compared the predicted creatinine clearance from same equations & nomogram to their measured values. These equations are -

1. Creatinine Clearance = $\frac{100}{Scr\ (mg\%)} - 12$ (ml/min/1.73 mt^2) (Jelliffe, 1971)[16]

2. Creatinine clearance = $\frac{98-16\ \frac{(Age-20)}{20}}{Scr\ (mg\%)}$ (ml/min/1.73 mt^2) -(Jelliffe, 1973)[15]

3. Creatinine clearance = $\frac{24.3}{Scr(mg\%)} - 1.8$ (ml/min/1.73 mt^2) =(Edward & Whyte, 1953)[8]

The predicted creatinine clearance by equation no. 3 Vs measured was not presented by Cockcroft & Gault.

Hackler and Associates[9] listed most common causes of decreased renal function in paraplegics as, pyelonephritis, renal amyloidosis, renal calculus disease, non obstructive hydronephrosis and vesicoureteral reflux[23,22]. The comparative studies have been done in paraplegics with vesicoureteral reflux or without[22,9,13].

In 1979 Wheeler and Schainer advised that urine method to asses creatinine clearance may actually be preferable to traditional method in the routine setting[21].

R.W. Jelliffe had shown that bed side estimation of creatinine clearance to calculate the drug doses, was necessary[15]. The equation was compared with a computer programme for estimation of creatinine clearance[14].

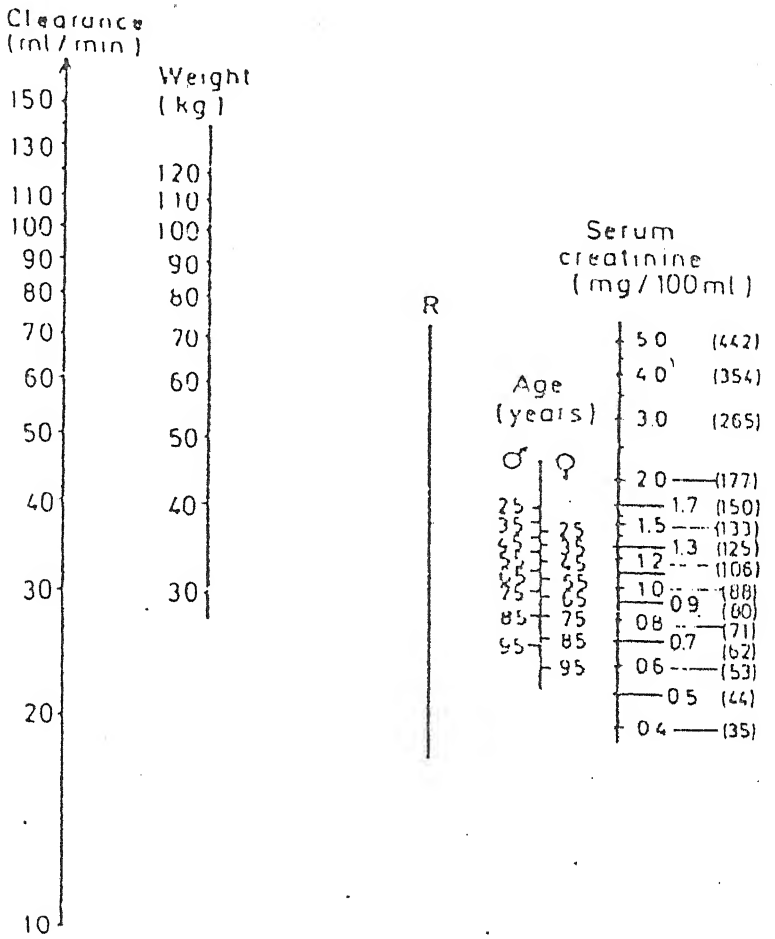
This simple equation also agrees with nomogram developed by Siersback - Nielsen and Collagues.

A computer assisted programme for Gentamicin & Kannamycin therapies in normal and reduced renal function has been given by Jelliffe R.W., Night R, Buell J, Kalaba R, and Rockwell R[17,20].

Biological half life of drug primarily excreted by the kidney, is prolonged in patients with impaired renal functions, in some instances alternate pathways of metabolism become increasingly important. These informative data are shown in tabular form by Bennett et al[33].

The toxicity of digitalis in elderly is due to decreased creatinine production will cause serum creatinine in normal range despite of decreased glomerular filtration rate (GFR)[10].

In 1974 Kampmann Siersback-Nielsen, Kristensen & Monson[19] reported the variation in creatinine clearance according to age, sex and weight and creatinine clearance were evaluated in hospitalised 368 patients with normal renal function and 106 with abnormal renal function. They were able to generate a popular nomogram -



"Nomogram for rapid evaluation of endogenous Creatinine clearance"

With a ruler join weight to age, keep ruler at crossing point of line marked R. Then move the right hand side of the ruler to the appropriate serum creatinine value and read the patients clearance from the left side of the Nomogram.

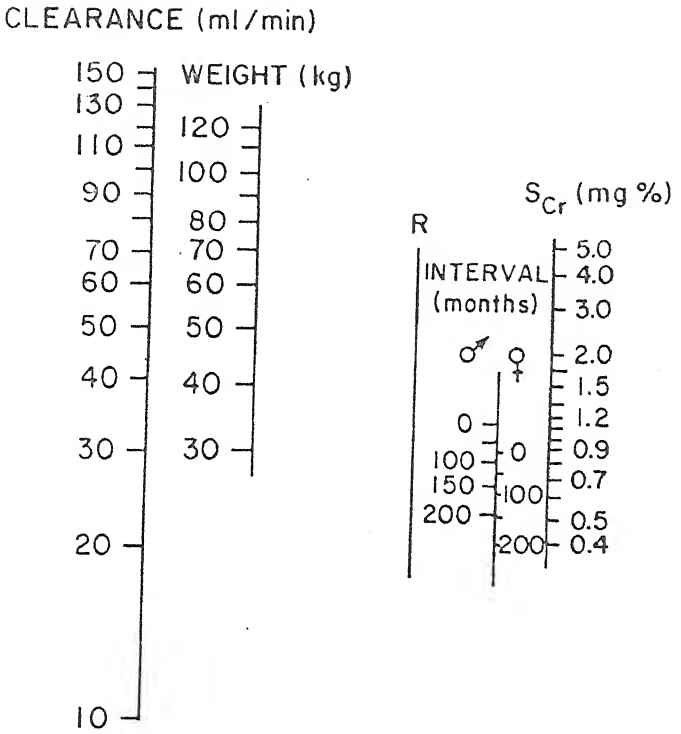
Body weight, urinary volume and creatinine excretion increase with age to a maximum level in both male and female. Urinary excretion gradually decreases with age in male (further) and significantly reduce from the maximum level by eight decade. A similar, less well defined pattern occur in female. The creatinine out put significantly become higher in male than female[4].

Previous attempts to predict creatinine clearance in spinal cord injury patients have been reported.

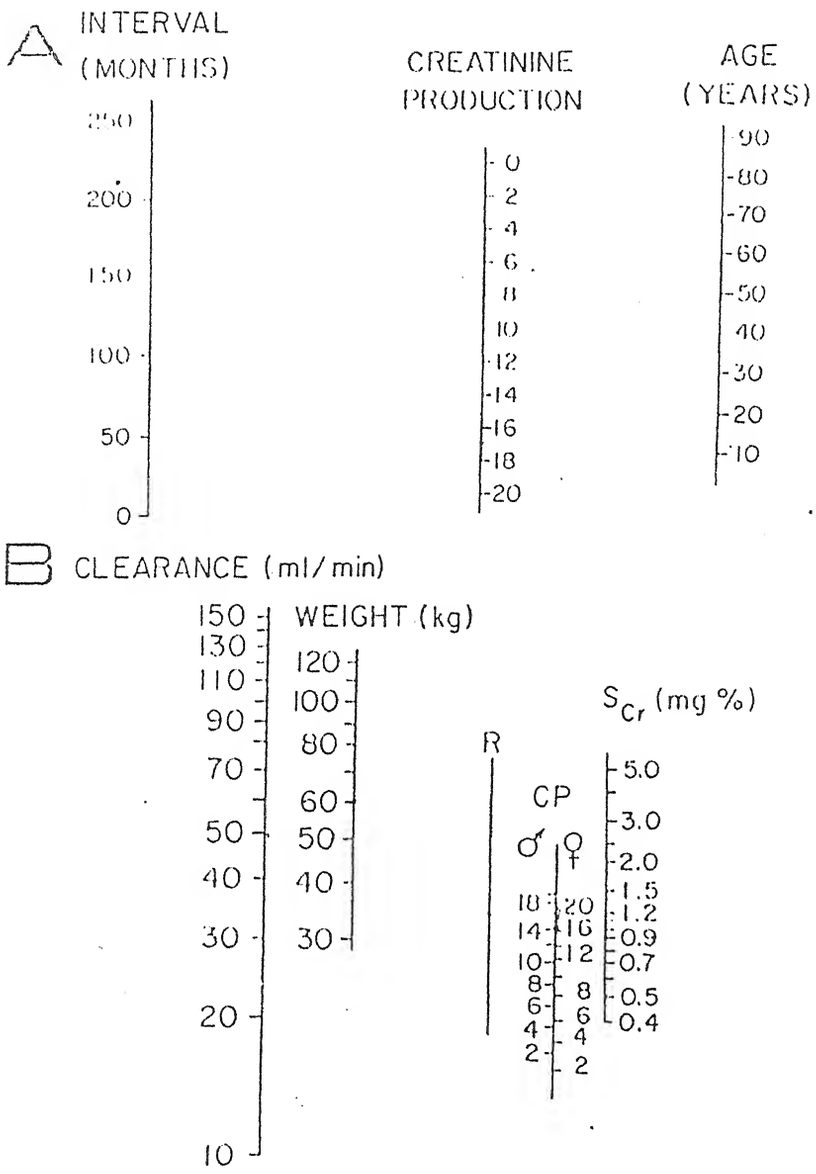
In 1982 Sawyer & Hutchins[34] examined 5 quadriplegics 9 paraplegics, 2 stroke patients and 2 patients suffering from multiple Sclerosis. The predicted creatinine clearance levels exceeded the true creatinine clearance by 31 percent when actual body mass was used. If lean body mass was used, instead of actual body weight, predicted creatinine clearance exceeded measured levels by 19 percent.

In 1983 Mirhamadi & Associates[25] examined the validity of the Cockcroft & Gault formula to predict creatinine clearance in 36 male quadriplegics and 22 male paraplegics. The predicted exceeded the measured creatinine clearance by 67% in quadriplegics and 26% in paraplegics. Therefore, they applied a correlation factor that would adjust the Cockcroft & Gault predicted creatinine clearance. If the patient was quadriplegic, the Cockcroft & Gault predicted creatinine clearance value was multiplied by 0.6 and if paraplegics, by 0.8.

In 1986 Kohler et al[26] studied 101 spinal cord injury patients (79 male; 22 female; 43 quadriplegic 58 paraplegics) found that Kampmann and Associates nomogram was improper to spinal cord injury patients to predict creatinine clearance and they recorded a new equation and nomogram.

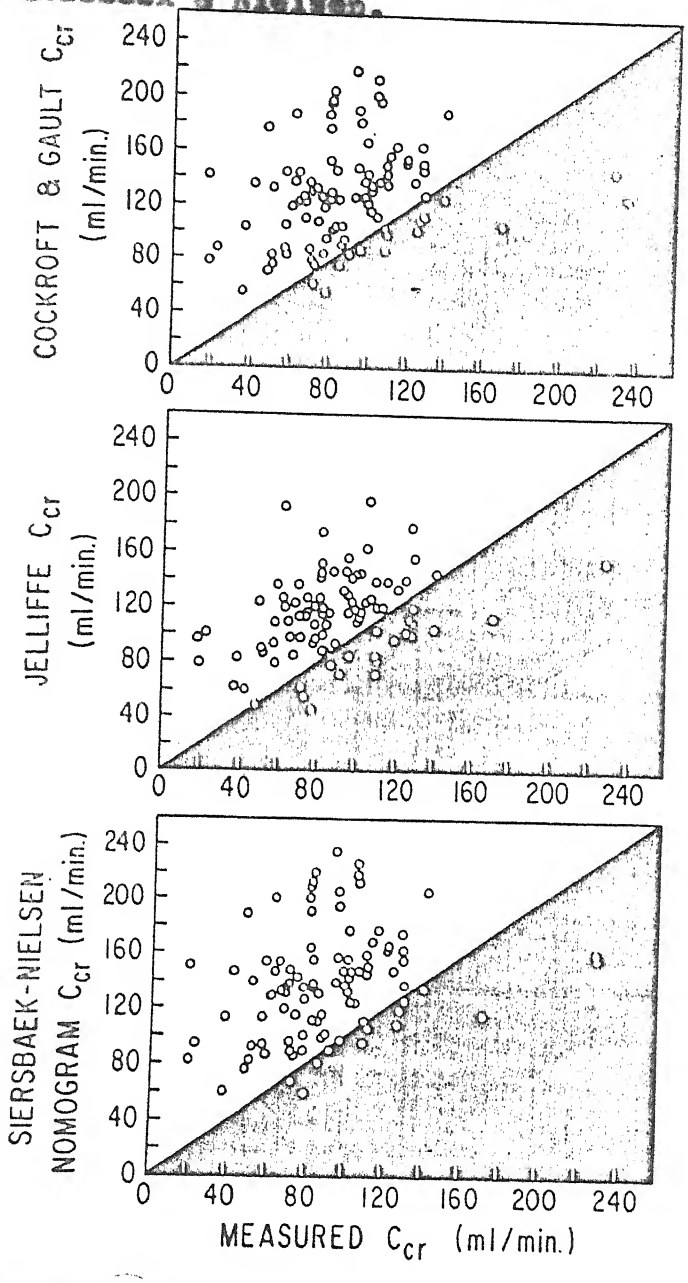


Nomogram for evaluation of creatinine clearance in quadriplegics. With ruler, connect patient weight with interval of injury for appropriate sex. Note point of intersection on R line and keep ruler there (this is pivot point). Turn right end of ruler to appropriate serum creatinine (S_{Cr}) value. Point where ruler intersects scale at left side will indicate clearance in ml. per minute.

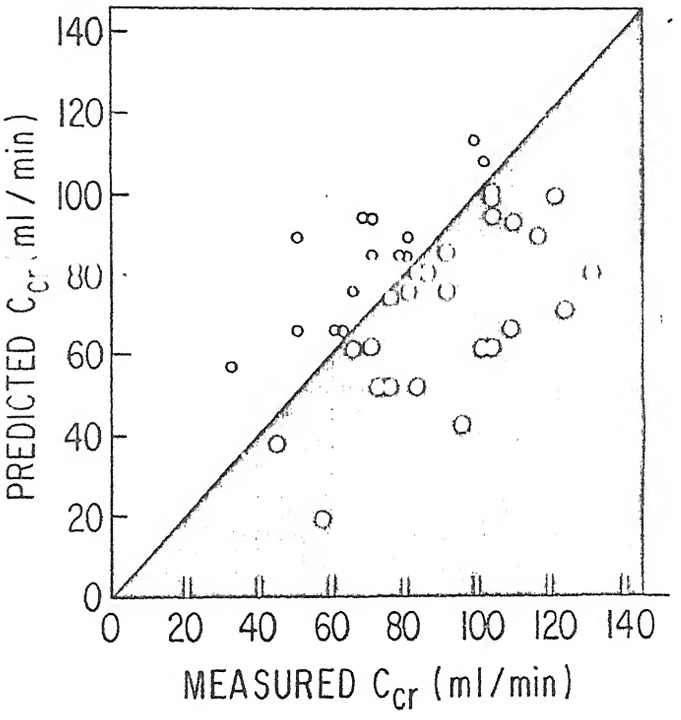


Nomogram for evaluation of creatinine clearance in paraplegics. A, with ruler, connect interval of injury to patient age to determine creatinine production. B, once creatinine production is determined, connect creatinine production (CP) for appropriate sex to patient weight. Note point of intersection on R line and keep ruler there. Turn right end of ruler to appropriate serum creatinine (S_{Cr}) value and left scale will indicate clearance in ml. per minute.

Mohler & Associates compared measured creatinine clearance Vs predicated, to Cockcroft & Gault, Jelliffe & nomogram of Siersbaek & Nielsen.



Predicted versus measured creatinine clearance (C cr). Creatinine clearance predicted by 3 popular nomograms or equations is plotted as function of actual creatinine clearance as measured in 101 spinal cord injury pts. Open circles on white background indicate predicted creatinine clearance that exceeds measured clearance. Conversely, white circles on black background indicate predicted creatinine clearance that is less than measured clearance.



predicted versus measured creatinine clearance (Cer). Creatinine clearance predicted by equations is plotted as function of actual measured creatinine clearance in 38 spinal cord injury patients.

In 1968 Mahler , Ellison and Flangan[27] have studied 6 predicted equation by various workers and reported that Sawyer & Hutchins equation is better than others.

In 1990 Maji et al observed that in spinal cord injury patients, urinary creatinine production was decreased but they could not explain its relation with age, sex or body weight[10].

MATERIAL AND METHODS

MATERIAL & METHODS

The parameters of age (years), sex, height (cm), weight (kg), serum creatinine (mg%) and 24 hour urinary creatinine production (mg / kg/ 24 hour) were measured in 28 consecutive spinal cord injury patients (15 male, 13 female, 12 quadriplegics and 16 paraplegics) admitted to Orthopaedic wards of M.L.B. Medical College, Hospital, Jhansi.

Serum and urinary creatinine levels were quantitated by Jaffe Method without deproteinization. All of the subjects had stable renal function at the time of inclusion of case into the study.

The creatinine production of these patients was compared to age and sex matched neurologically intact hospitalized patients reported by Rampmann & Associates. The difference in creatinine production was analysed for statistical significance by the unpaired student t' test.

The various factors that might influence the 24 hour urinary creatinine production in spinal cord injury patients were examined sequentially. Quadriplegics were compared to paraplegics and male to female by unpaired student t'test. The effects of age upon creatinine production were examined by regression analysis.

METHOD

JAFFE METHOD WITHOUT DEPROTEINIZATION :

2 point reaction rate measurement in 2 minutes (Bartels H. et al, 1971).

Test Principle :

Creatinine forms a coloured complex with picrate in alkaline medium. The rate of formation of the complex is measured.

Sample Material :

Serum, heparinised plasma, urine.

Reagents :

Sl. No.	Contents	Initial concentration of solutions
1.	Standard (Creatinine)	2 mg/100 ml (177 micromol/lit.)
2.	Picric Acid	35 m mol/ lit.
3.	NaoH	0.32 mol/lit.

Preparation and stability of reagents:

1. Used reagents undiluted and stable up to the expiry date specified when stored at + 15 to + 25°c.

2. Diluted 1 part by volume of NaoH with 4 parts by volume of redist. water.

3. Prepared a 1 + 1 mixture of picric acid with diluted NaoH at least 30 minutes before starting the assay.

Sample Preparation :

Hemolysis interferes with test.serum or plasma can be stored upto 24 hours at + 4°c.

Dilute fresh urine 1 + 49 with redist. water.

Procedure :

Wave length Hg 492 nm (490 - 510 nm)

Spectrophotometer : 490 nm

Curette : 1 cm light path

Temperature : + 25°c

One standard is sufficient for each reagent mixture.

Pipette into curette	Standard	Sample
Reagent mixture	2.0 ml	2.0 ml
Standard solution	0.2 ml	-
Sample	-	0.2 ml

Mixed and stopwatch is started at the same time. After 30 seconds absorbance A1 is read of standard and sample respectively and exactly 2 minutes later absorbance A2 is read of standard & sample.

A2 - A1 A sample or A standard

If the creatinine concentration exceeded to 10 mg% in serum/plasma or 500 mg% in urine.

Then the serum, plasma or diluted urine was diluted 1 + 4 with .9% Nacl solution and repeat assay (result x 5).

Calculation :

Creatinine concentration (c) in serum or plasma.

$$C = 2.0 \times \frac{A \text{ sample}}{A \text{ standard}} \quad (mg / 100 ml)$$

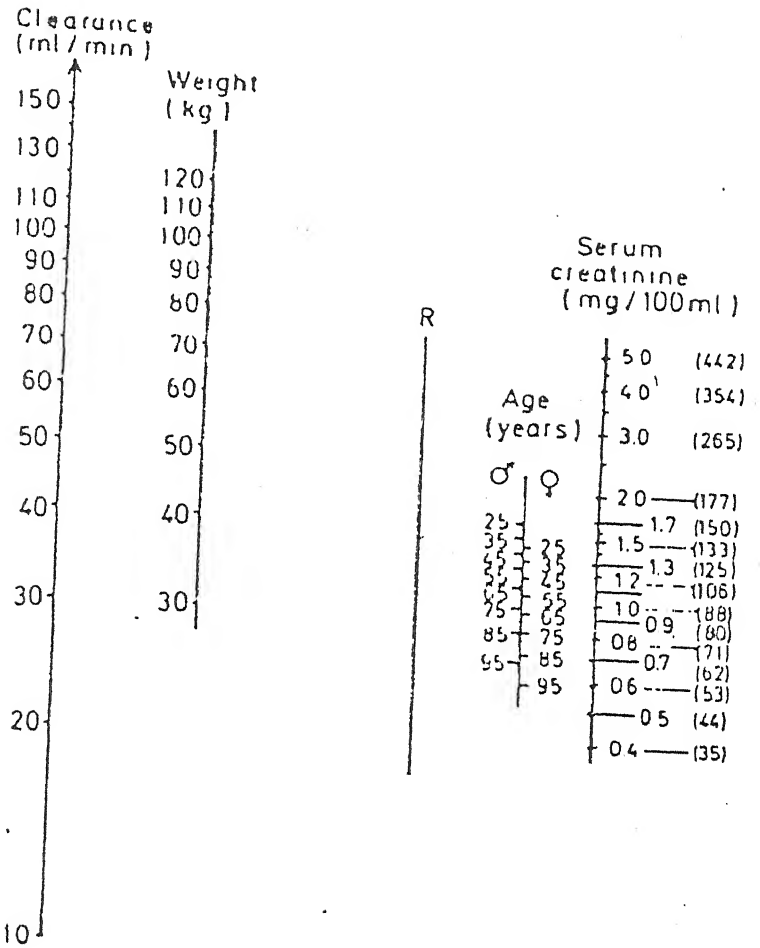
Creatinine concentration (c) in urine.

$$C = 100 \times \frac{A \text{ sample}}{A \text{ standard}} \quad (mg / 100 ml)$$

CREATININE CLEARANCE : It can be measured and predicted.

$$\text{Measured Cr. Cl.} \ (Ml/Min) = \frac{CR. \text{ mg\% in urine}}{CR. \text{ mg\% in serum}} \times \frac{\text{Urine volume Ml/24 hour}}{24 \times 60}$$

Nomogram reported by Kampmann and Associates was used to predict creatinine clearance.



"Nomogram for rapid evaluation of endogenous Creatinine clearance"

With a ruler, join weight to age, keep ruler at crossing point of line marked R. Then move the right hand side of the ruler to the appropriate serum creatinine value and read the patients clearance from the left side of the nomogram.

OBSERVATIONS

OBSERVATION

The present work was under taken on spinal cord injury patients admitted to Orthopaedic and emergency wards of M.L.B. Medical College Hospital, Jhansi during a period of one year viz, from July, 1991 to June, 1992.

The study group consisted of 28 spinal cord injury patients including 15 male, 13 female and 16 pareplegics and 12 quadriplegics. All the patients of spinal cord injury were not recovered from peralysis. The control group was taken from the age and sex matched neurologically intact hospitalised 123 patients (out of 474) reported by Kampmann & Associates (1974). It consisted of 54 male and 69 female (Table - 1).

Table - 1, shows the creatinine production (both in male and female) in defferent age groups of neurologically intact hospitalised patients studied by Kampmann & Associates.

Table - 1

CREATININE PRODUCTION IN CONTROL GROUP

Sl. No.	Age groups	No. of patients	Body weight (kg)	Serum creat-inine (mg%)	Creatinine production (mg/kg/day)
MALE					
1.	20 - 29	12	68.4	0.99±0.16	23.8±2.3
2.	30 - 39	10	70.9	1.14±0.22	21.9±1.5
3.	40 - 49	32	77.5	1.10±0.20	19.7±3.2
FEMALE					
1.	20 - 29	32	58.1	0.89±0.17	19.7±3.9
2.	30 - 39	14	60.9	0.91±0.17	20.4±3.9
3.	60 - 69	23	65.4	0.97±0.17	12.9±2.6

A. Creatinine Production in Spinal Cord Injury patients:

(a) Male and Female patients -

Table - 2 depicts the creatinine production in 15 male spinal cord injury patients in relation to age (years) height (cm), weight (Kgs), urinary creatinine (mg%), serum creatinine (mg%), interval since injury (weeks) and 24 hour urinary volume (ml).

Table - 2

CREATININE PRODUCTION IN MALE SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	HEIGHT (CM.)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	INTERVAL (WEEKS)	URINE VOLUME (ML.)	CR. PRODUCTION	
								TOTAL-MG	MG/KG/DAY
1	36	170	49	61.66	0.76	45	1200	739.92	15.10
2	48	166	57	37.86	0.70	9	2100	795.06	13.94
3	35	153	50	28.26	0.80	190	2000	565.20	11.30
4	25	160	46	97.15	0.80	30	800	777.20	16.89
5	25	145	35	27.90	0.60	48	2150	599.85	17.13
6	30	162	55	30.12	0.70	40	3000	903.60	16.42
7	40	165	58	95.55	1.00	7	900	859.95	14.82
8	35	168	48	37.73	0.80	50	2000	754.60	15.72
9	40	170	47	20.50	1.00	8	3800	779.00	16.57
10	35	165	50	28.17	0.40	38	3000	845.00	16.90
11	45	156	50	20.67	0.60	28	4000	826.80	16.53
12	20	162	54	45.34	0.80	27	2000	906.80	16.89
13	23	165	50	77.30	0.80	15	1100	850.30	17.00
14	45	160	52	26.00	0.40	50	3200	832.00	16.00
15	32	160	46	20.00	0.50	12	4000	800.00	17.39
MEAN	34.26	161.8	49.8	43.63	0.71	39.8	2350	15.90	MG/KG/DAY
+-S.D.	+-8.22	+-6.43	+-5.36	+-25.11	+-0.17	+-42.98	+-1059.19	+-1.54	

The mean age was 34.26 ± 8.22 years. The height was 161.9 ± 6.43 cm. Mean weight was recorded as 49.8 ± 5.34 kgs. The values of urinary creatinine were recorded as 43.63 ± 25.11 mg%, while serum creatinine was 0.71 ± 0.17 mg%. In all these patients the interval since injury was noticed as 39.8 ± 42.96 weeks. The value of 24 hours urinary volume was 2350 ± 1059.19 ml. The creatinine production was measured as 15.9 ± 1.36 mg/kg/day.

Table - 3 describes the mean creatinine production (mg/kg/day) in male spinal cord injury patients in relation to different age groups. The mean creatinine productions in age groups of 20 to 29 years.

Table - 3

MALE SPINAL CORD INJURY PATIENTS

Sl. No.	Age groups (years)	No. of patients	Mean Creatinine Production (mg/kg/day)	S.D.
1.	20 - 29	4	16.95	0.1265
2.	30 - 39	6	14.47	2.009
3.	40 - 49	3	14.57	0.359

30 to 39 years and 40 to 49 years were 16.95 ± 0.1265, 14.47 ± 2.009 and 14.57 ± 0.359 mg/kg/day respectively.

Table 4 shows the creatinine production in 13 female spinal cord injury patients in relation to age (gm) height (cm), weight (kgs), urinary creatinine(mg%), serum creatinine, interval after injury (weeks) and 24 hours urine volume (ml). The mean age and height were 42.46 ± 17.96 (year) and 152.15 ± 3.05 cm respectively. Mean weight was recorded 45 ± 13.16 kgm. The value of urinary creatinine was recorded as 32.72 ± 16.83 mg%, while serum creatinine was 0.77 ± 0.14 mg%. In these patients the interval since injury and 24 hour urinary volume were 10.6 ± 3.66 weeks and 1855 ± 431.32 ml respectively. The mean measured volume for creatinine production was 12.87 ± 3.60 mg/kg/day.

Table - 4

CREATININE PRODUCTION IN FEMALE SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	HEIGHT (CM.)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	INTERVAL (WEEKS)	URINE VOLUME (ML.)	CR. PRODUCTION	
								TOTAL-MG	MG/KG/DAY
1	64	153	50	19.00	0.72	13	2000	380.00	7.60
2	66	154	40	22.64	0.74	14	2000	452.80	11.32
3	65	153	33	15.50	0.70	14	2500	387.50	11.74
4	30	145	42	18.30	1.00	5	2822	512.40	12.20
5	36	152	44	28.17	0.70	7	2000	563.40	12.80
6	20	150	30	41.25	0.98	11	1500	618.75	20.60
7	24	153	51	30.15	0.70	10	1100	572.85	11.53
8	35	156	80	83.13	0.60	7	1500	1246.95	15.58
9	35	153	45	32.63	0.70	6	1800	587.84	13.06
10	25	150	32	45.73	1.00	7	1200	548.76	17.14
11	20	148	30	24.56	1.00	15	2020	496.11	16.53
12	67	155	52	29.78	0.62	13	1400	417.04	8.02
13	65	156	56	34.60	0.66	16	1500	519.12	9.27
MEAN	42.46	152.15	45	32.72	0.77	10.6	1855	12.87	MG/KG/DAY
+-S.D.	+-17.96	+-3.05	+-13.16	+-16.83	+-0.14	+-3.66	+-431.32	+-3.60	

Table - 5 depicts the mean creatinine production in female spinal cord injury patients in relation to different age groups. The mean values for creatinine productions in age groups 20 to 29, 30 to 39 and 40 to 49 years were 18.09 ± 1.792, 13.03 ± 1.378 and 9.59 ± 1.681 mg/kg/day respectively.

Table - 5

FEMALE SPINAL CORD INJURY PATIENTS

Sl. No.	Age groups (yrs)	No. of patients	Mean creatinine production (mg/kg/day)	S.D.
1.	20-29	03	18.09	1.792
2.	30-39	05	13.03	1.378
3.	40-49	05	09.59	1.681

Table 6 and 7 describe the details of creatinine production (mg/kg/day) in 149 males and 219 females with serum creatinine $\angle$ 1.4 mg% and 51 male and 55 females with elevated serum creatinine in different age groups of males (table 6) and females (table 7) in relation to body weight (kg), serum creatinine (mg%) and urinary creatinine (mg.). All these 474 controls were neurologically intact hospitalised patients studied by Kampmann and Associates (1974).

Table - 6

CREATININE PRODUCTION IN MALE OBSERVED BY KAMPMANN & ASSOCIATES

AGE (YR)	n	BODY WEIGHT (KG.)	SERUM (CR.MG%)	URINARY CREATININE			a	URINARY
				MG/24H	MG/KG/24H	MG/KG/MIN	n	CREATINE MG/KG/24H
20 - 29	12	68.4	0.99+-.16	1625+-137	23.8+-2.3	1.65	0	-
30 - 39	10	70.9	1.14+-.22	1520+-130	21.9+-1.5	1.52	4	-21.7+-3.7
40 - 49	32	77.5	1.10+-.20	1544+-421	19.7+-3.2	1.37	7	21.9+-2.4
50 - 59	37	75.7	1.16+-.17	1445+-252	19.3+-2.9	1.34	14	19.8+-2.3
60 - 69	23	73.4	1.15+-.14	1252+-364	16.6+-2.9	1.17	13	19.1+-3.8
70 - 79	18	69.5	1.03+-.22	919+-132	14.2+-3.0	0.99	10	13.2+-2.7
80 - 89	12	56.3	1.06+-.25	651+-238	11.7+-4.0	0.81	1	9.0
90 - 99	5	67.6	1.20+-.16	612+-188	09.4+-3.2	0.65	2	10.7+-2.1

Table - 7

CREATININE PRODUCTION IN FEMALE OBSERVED BY KAMPMANN & ASSOCIATES

AGE (YR)	n	BODY WEIGHT (KG.)	SERUM (CR.MG%)	URINARY CREATININE			a	URINARY CREATINE
				MG/24H	MG/KG/24H	MG/KG/MIN	n	MG/KG/24H
20 - 29	32	58.1	0.89+-.17	1135+-224	19.7+-3.9	1.37	0	
30 - 39	14	60.9	0.91+-.17	1218+-191	20.4+-3.9	1.42	4	19.4+-4.7
40 - 49	48	60.1	1.00+-.24	1056+-256	17.6+-3.9	1.22	10	16.5+-3.6
50 - 59	34	67.8	0.99+-.26	989+-246	14.9+-3.6	1.04	11	16.7+-2.8
60 - 69	23	65.4	0.97+-.17	871+-283	12.9+-2.6	0.90	13	15.4+-3.4
70 - 79	27	58.3	1.02+-.23	685+-184	11.8+-2.2	0.82	12	10.1+-3.9
80 - 89	32	55.3	1.05+-.22	578+-154	10.7+-2.5	0.74	4	11.3+-1.0
90 - 99	9	52.4	0.91+-.12	433+-113	08.4+-1.4	0.58	1	12.9

The age and sex matched groups of individuals were selected and served as controls. The detail is in table - 1.

In table - 8 the comparison of creatinine production in males and females of study groups versus control group is depicted.

In male category, the differences in creatinine productions in different age groups viz 20 to 29, 30 to 39 and 40 to 49 years were (df = 14, t = 9.28, p< .001), (d.f. = 14, t = 14.81, p<.001) and (df = 35, t = 4.34, p<.001). The difference in each group was highly signifi-cant.

Table - 8

CREATININE PRODUCTION (mg/kg/day)

S. NO.	AGE GROUP (YRS)	NO. OF PTS	MEAN C.P. (+-S.D.)	NO. OF PTS	MEAN C.P. (+-S.D.)	Df.	t	P
	MALE							
1	20 - 29	4	16.95+-.1265	12	23.9+-2.3	14	9.28	<0.001
2	30 - 39	6	15.47+-2.009	10	21.9+-1.5	14	14.81	<0.001
3	40 - 49	5	14.57+-.359	32	19.7+-3.2	35	4.34	<0.001
	FEMALE							
1	20 - 29	3	18.09+-1.792	32	19.7+-3.9	33	0.77	>0.40
2	30 - 39	5	13.03+-1.378	14	20.4+-3.9	17	6.21	<0.001
3	60 - 69	5	9.59+-1.681	23	12.9+-2.6	26	3.48	<0.01

In female category, the difference in creatinine production in 20 to 29 years was (df = 33, t = .77 p 7.40) not statistically significant. There were only 3 patients in study group. Therefore, they could not be examined statistically. In 30 to 39 years the difference was (d.f. = 17, t = 6.21, p<.001) highly significant. In 60 to 69 years, it was (d.f. 26, t = 3.48, p <.01) also significant.

Table 9 shows the difference in creatinine production among males and females of spinal cord injury patients in matching age groups (studied group).

Table - 9

COMPARISON OF C.P. IN MALE & FEMALE SPINAL CORD INJURY PATIENTS

Sl. No.	Age group (yrs)	MALE No.of pts.	MALE C.P. (mg/kg/day) mean ± S.D.	FEMALE No.of pts.	FEMALE C.P. (mg/kg/day) Mean ± S.D.
1.	20-29	4	16.95± 0.1265	3	18.09 ± 1.792
2.	30-39	6	15.47± 2.009	5	13.03 ± 1.379
	Total	10	16.06± 1.303	8	14.92 ± 1.516

d.f. = 16, t = 1.72, p7.05

The difference in creatinine production (d.f.=16, t=1.72, p 7.05) in between male and female spinal cord injury patients was not statistically significant.

(b) Paraplegic and Quadriplegic patients :

Table 10 depicts the creatinine production (mg/kg/day) in 16 paraplegics (both male and female) spinal cord injury patients in relation to age (years) height (cm), weight (kgs), urinary creatinine (mg%), serum creatinine (mg%), interval after injury (weeks) and 24 hour urinary volume (ml).

For this group of patients the mean age was 31.81 ± 6.77 years and the height was 155 ± 8.21 cm. Mean weight was noticed 44.23 ± 10.92 kgs. The values of urinary creatinine were recorded as 45 ± 24.63 mg% while serum creatinine was 0.80 ± 0.14 mg%. Interval since injury and 24 hour urine volume in all paraplegics were 30.93 ± 43.47 weeks and 2092.39 ± 653.86 ml respectively. The creatinine production was measured as 15.88 ± 1.83 mg/kg/day.

In table 11, the creatinine production in 12 quadriplegics in relation to age (years), height (cm), weight (kg), urinary creatinine(mg%), serum creatinine (mg%), interval since injury (weeks) and 24 hour urine volume (ml) has been described.

Table - 10

CREATININE PRODUCTION IN PARAPLEGIC SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	HEIGHT (CM.)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	INTERVAL (WEEKS)	URINE VOLUME (ML.)	CR. PRODUCTION	
								TOTAL-MG	MG/KG/DAY
1	30	145	33.00	18.30	1.00	5	2800	512.19	15.52
2	36	152	36.00	28.17	0.70	7	2000	563.40	15.65
3	20	150	30.00	41.25	0.98	11	1500	618.00	20.60
4	34	153	35.80	30.15	0.70	10	1900	572.80	16.00
5	36	170	49.00	61.66	0.76	45	1200	739.90	15.10
6	48	166	57.00	37.86	0.70	9	2100	794.58	13.94
7	35	153	50.00	28.26	0.80	190	2000	565.00	11.30
8	25	145	46.00	97.15	0.80	30	800	776.94	15.89
9	35	156	80.00	83.13	0.60	7	1500	246.40	15.58
10	25	145	35.00	27.90	0.60	48	2150	599.55	17.13
11	30	162	55.00	30.12	0.70	40	3000	903.10	16.42
12	40	165	58.00	95.55	1.00	7	900	859.56	14.82
13	35	153	37.00	32.63	0.70	6	1800	587.19	15.87
14	25	156	32.00	45.73	1.00	7	1200	548.48	17.14
15	20	148	26.00	24.56	1.00	15	2020	429.18	16.53
16	35	168	48.00	37.73	0.80	50	2000	754.86	15.72
MEAN	31.81	155	44.23	45.00	0.80	30.43	2092.37	15.88 MG/KG/DAY	
+-S.D.	+-6.77	+-8.21	+-10.92	+-24.63	+-0.14	+-43.47	+-653.86	+-1.83	

Table - 10

CREATININE PRODUCTION IN PARAPLEGIC SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	HEIGHT (CM.)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	INTERVAL (WEEKS)	URINE VOLUME (ML.)	CR. PRODUCTION	
								TOTAL-MG	MG/KG/DAY
1	30	145	33.00	18.30	1.00	5	2800	512.19	15.52
2	36	152	36.00	28.17	0.70	7	2000	563.40	15.65
3	20	150	30.00	41.25	0.98	11	1500	618.00	20.60
4	34	153	35.80	30.15	0.70	10	1900	572.80	16.00
5	36	170	49.00	61.66	0.76	45	1200	739.90	15.10
6	48	166	57.00	37.86	0.70	9	2100	794.58	13.94
7	35	153	50.00	28.26	0.80	190	2000	565.00	11.30
8	25	145	46.00	97.15	0.80	30	800	776.94	15.89
9	35	156	80.00	83.13	0.60	7	1500	246.40	15.58
10	25	145	35.00	27.90	0.60	48	2150	599.55	17.13
11	30	162	55.00	30.12	0.70	40	3000	903.10	16.42
12	40	165	58.00	95.55	1.00	7	900	859.56	14.82
13	35	153	37.00	32.63	0.70	6	1800	587.19	15.87
14	25	156	32.00	45.73	1.00	7	1200	548.48	17.14
15	20	148	26.00	24.56	1.00	15	2020	429.18	16.53
16	35	168	48.00	37.73	0.80	50	2000	754.86	15.72
MEAN	31.81	155	44.23	45.00	0.80	30.43	2092.37	15.88	MG/KG/DAY
+-S.D.	+-6.77	+-8.21	+-10.92	+-24.63	+-0.14	+-43.47	+-653.86	+-1.83	

Table - 11

CREATININE PRODUCTION IN QUADRIPLEGIC SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	HEIGHT (CM.)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	INTERVAL (WEEKS)	URINE VOLUME (ML.)	CR. PRODUCTION TOTAL-MG	CR. PRODUCTION MG/KG/DAY
1	64	153	50	19.00	0.72	13	2000	380.00	7.60
2	66	154	40	22.64	0.74	14	2000	384.88	11.32
3	40	170	47	20.50	1.00	8	3800	778.79	16.57
4	35	165	50	28.17	0.60	38	3000	845.00	16.90
5	45	156	50	20.67	0.60	28	4000	826.50	16.53
6	20	162	54	45.34	0.80	27	2000	906.66	16.79
7	23	165	50	77.30	0.80	15	1100	850.00	17.00
8	45	160	52	26.00	0.60	50	3200	832.00	16.00
9	65	153	33	15.50	0.70	14	3500	887.42	11.74
10	32	160	46	20.00	0.60	12	4000	799.94	17.39
11	67	155	52	29.78	0.62	13	1400	417.02	8.02
12	65	156	56	34.60	0.66	16	1500	519.12	9.27
MEAN	47.25	159	46.45	29.95	0.70	20.6	2625	13.89	MG/KG/DAY
+-S.D.	+-16.90	+-5.28	+-7.91	+-16.26	+-0.29	+-12.07	+-975.25	+-3.70	

In these data the mean age and height were calculated 47.25 ± 16.99 year and 159 ± 5.20 cm respectively. The mean weight was recorded as 46.45 ± 7.91 kgs. The values of creatinine in urine and serum were found 29.95 ± 16.26 and 0.70 ± 0.29 mg. respectively. The value for 24 hour urine was recorded as 2625 ± 975.25 ml. In all quadriplegics the interval since injury was 20.6 ± 12.07 weeks and creatinine production was found 13.89 ± 3.70 mg/kg/day.

Table 12 shows the difference in creatinine production in quadriplegic and paraplegic spinal cord injury patients.

Table - 12

COMPARISON OF CREATININE PRODUCTION IN PARAPLEGIC AND QUADRIPLEGIC

Paraplegics			Quadriplegics		
No.of patients	Mean creatinine production	S.D.	No.of patients	Mean creatinine production	S.D.
16	15.88 mg/kg/day	1.83 mg/kg/day	12	13.89 mg/kg/day	3.70 mg/kg/day

d.f. = 26, t = 1.99, p>.05

The difference was (d.f. = 26, t = 1.99, p>.05) not significant.

(C) The relationship of creatinine production with age and interval since injury in spinal cord injury patients (Paraplegics & Quadriplegics).

C.(a) - Relationship between interval after spinal cord injury and creatinine production in paraplegics and quadriplegics.

(i) <u>Paraplegics</u> - Figure 1 and table 13 demonstrate a relationship in between creatinine production mg/kg/day and interval after spinal cord injury weeks. Interval is denoted on X-axis and creatinine production mg/kg/day is on Y-axis. The density of dots shows that as the interval increases, the creatinine production decreases. Best-fit line is constructed by regression analysis. It shows a significant correlation r = -0.565, p<.05 between creatinine production and interval after injury.

The square of correlation coefficients (r^2 = 0.31) indicates that approximately 31 percent variation in creatinine production in paraplegics can be explained by the interval after injury. The regression equation is Y = 16.58 -'0 231 X.

Table - 13

CREATININE PRODUCTION IN PARAPLEGICS VERSUS INTERVAL SINCE INJURY

Sl. No.	Sex	Interval since injury (weeks)	Creatinine Production (mg/kg/day)
1.	F	05	15.52
2.	F	07	15.65
3.	F	11	20.60
4.	F	10	16.00
5.	M	45	15.10
6.	M	09	13.94
7.	M	190	11.30
8.	M	30	16.89
9.	F	07	15.89
10.	M	48	17.13
11.	M	40	16.42
12.	M	07	14.82
13.	F	06	15.87
14.	F	07	17.14
15.	F	15	16.53
16.	M	50	15.72

Figure-1

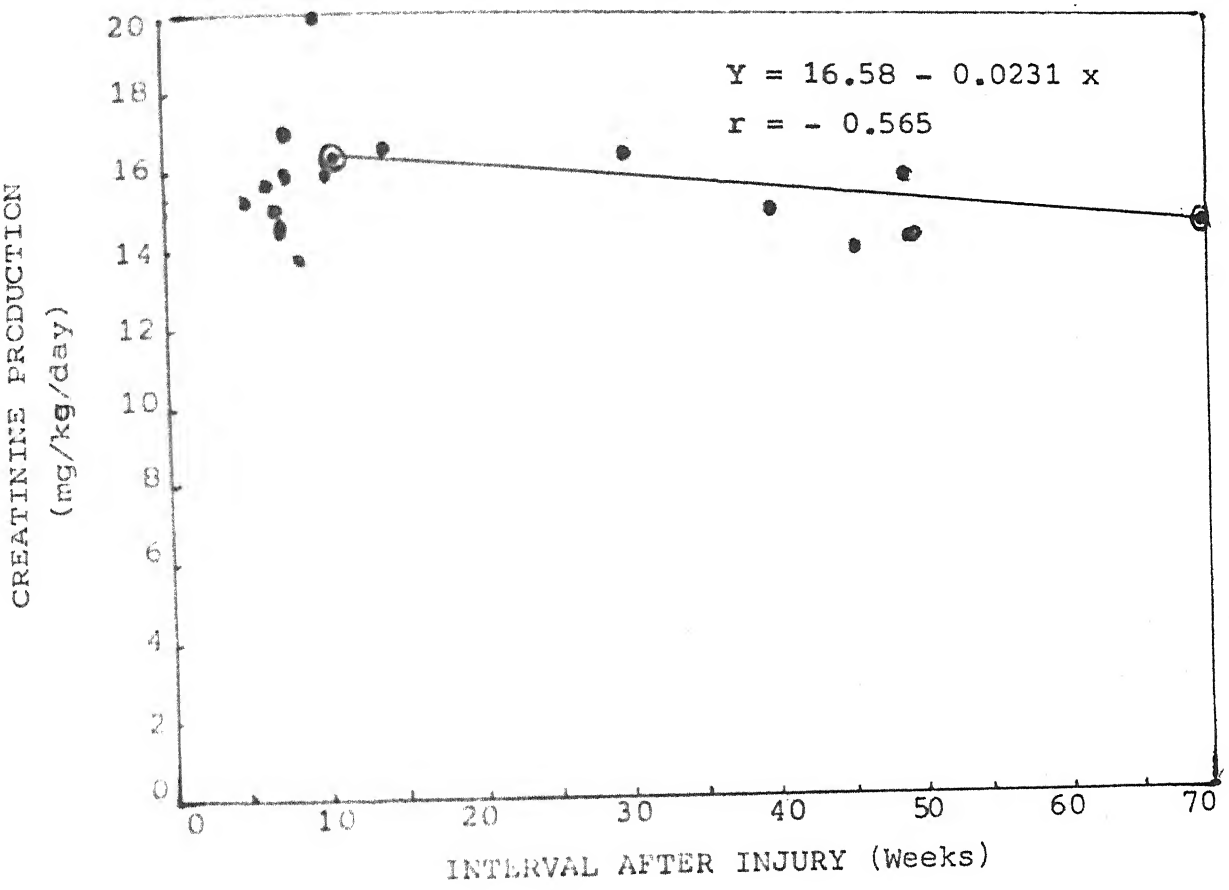
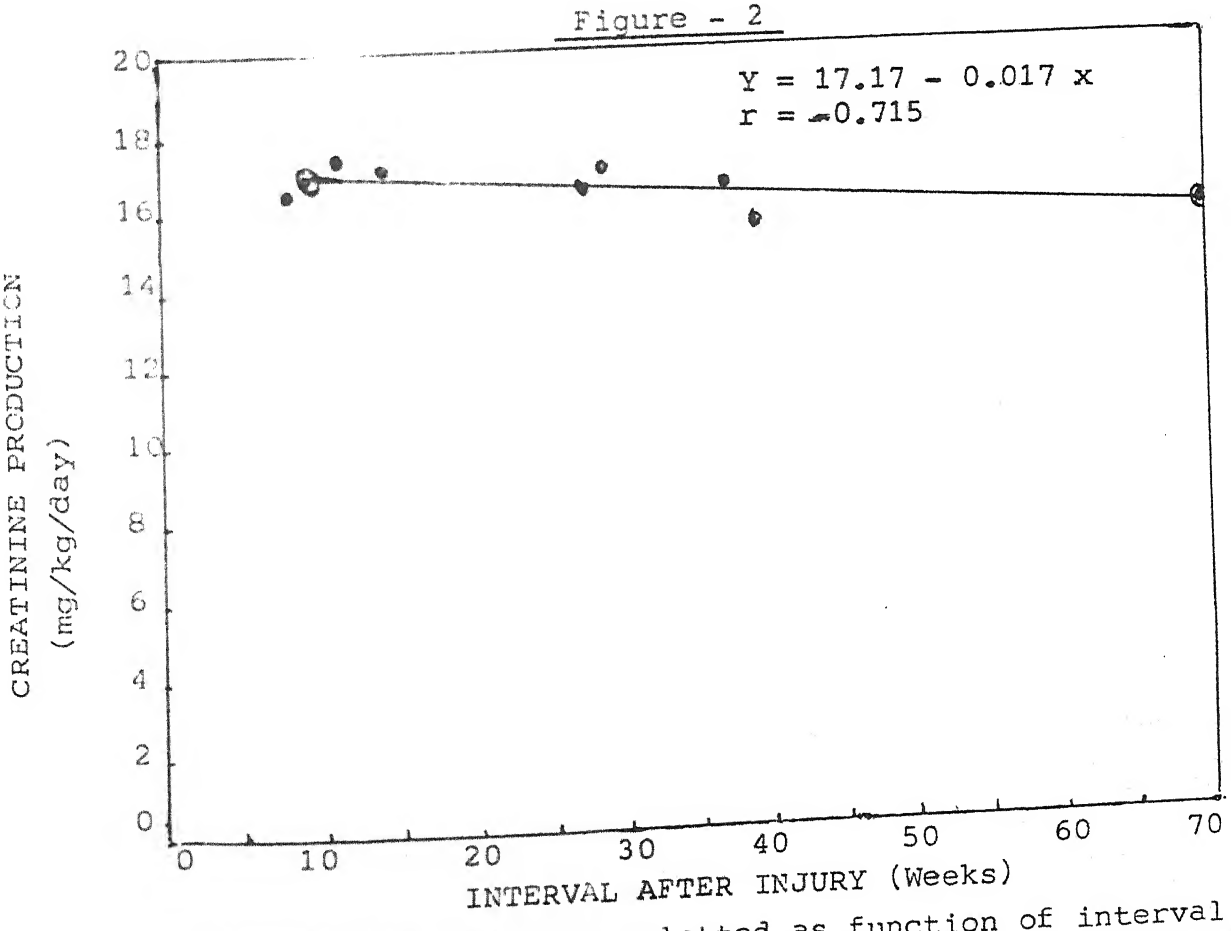


Figure - 2



Creatinine production plotted as function of interval after spinal cord injury. Best-fit line is constructed by regression analysis. Paraplegic (fig-1) Quadriplegic (fig-2).

(ii) Quadriplegics : Figure 2 and table 14 show the relationship in between quadriplegics and interval since injury (weeks). If the age group 60 years and above were included in regression analysis. The best-fit line was parallel to X-axis. So age group 60 years and above were excluded from regression analysis.

Table - 14

CREATININE PRODUCTION IN QUADRIPLEGIC VERSUS INTERVAL SINCE INJURY

Sl. No.	Sex	Interval since injury (weeks)	Creatinine production (mg/kg/24 hrs)
1.	M	08	16.57
2.	M	38	16.90
3.	M	28	16.83
4.	M	27	16.79
5.	M	15	17.00
6.	M	50	16.00
7.	M	12	17.39

The density of dots shows that as interval since injury increases, creatinine production decreases. Best-fit line is constructed by regression analysis. It shows a significant correlation ($r = -0.715$, $p < .05$) in between, creatinine production of quadriplegics and interval after injury.

The square of correlation coefficient (r^2 = .51) indicates that approximately 51 percent variation in creatinine production can be explained by the interval after injury in quadriplegics.

C. (b). Relationship between age & creatinine production in paraplegics and quadriplegics.

(i) Paraplegics : Figure 3 and table 15 indicate the creatinine production versus age in paraplegics.

In paraplegic the age of the patients correlated significantly with creatinine production (r = -0.652, p $<$.05). Again regression equation (Y = 20.93 - 0.159 x) is calculated and best-fit line is constructed which shows the decreasing creatinine production with increasing the age square of coefficient (r^2 = 0.425) indicate that 42.5 percent of the variation increatinine production may be explained for by age in paraplegics. The regression equation is as Y = 20.93 - 0.159 x.

Table - 15

CREATININE PRODUCTION IN PARAPLEGIC VERSUS AGE

Sl. No.	Age	Sex	Creatinine production
1.	30	F	15.52
2.	36	F	15.65
3.	20	F	20.60
4.	34	F	16.00
5.	36	M	15.10
6.	48	M	13.94
7.	35	M	11.30
8.	25	M	16.89
9.	35	F	15.80
10.	25	M	17.13
11.	30	M	16.42
12.	40	M	14.82
13.	35	F	15.87
14.	25	F	17.14
15.	20	F	16.53
16.	35	M	15.72

Figure - 3

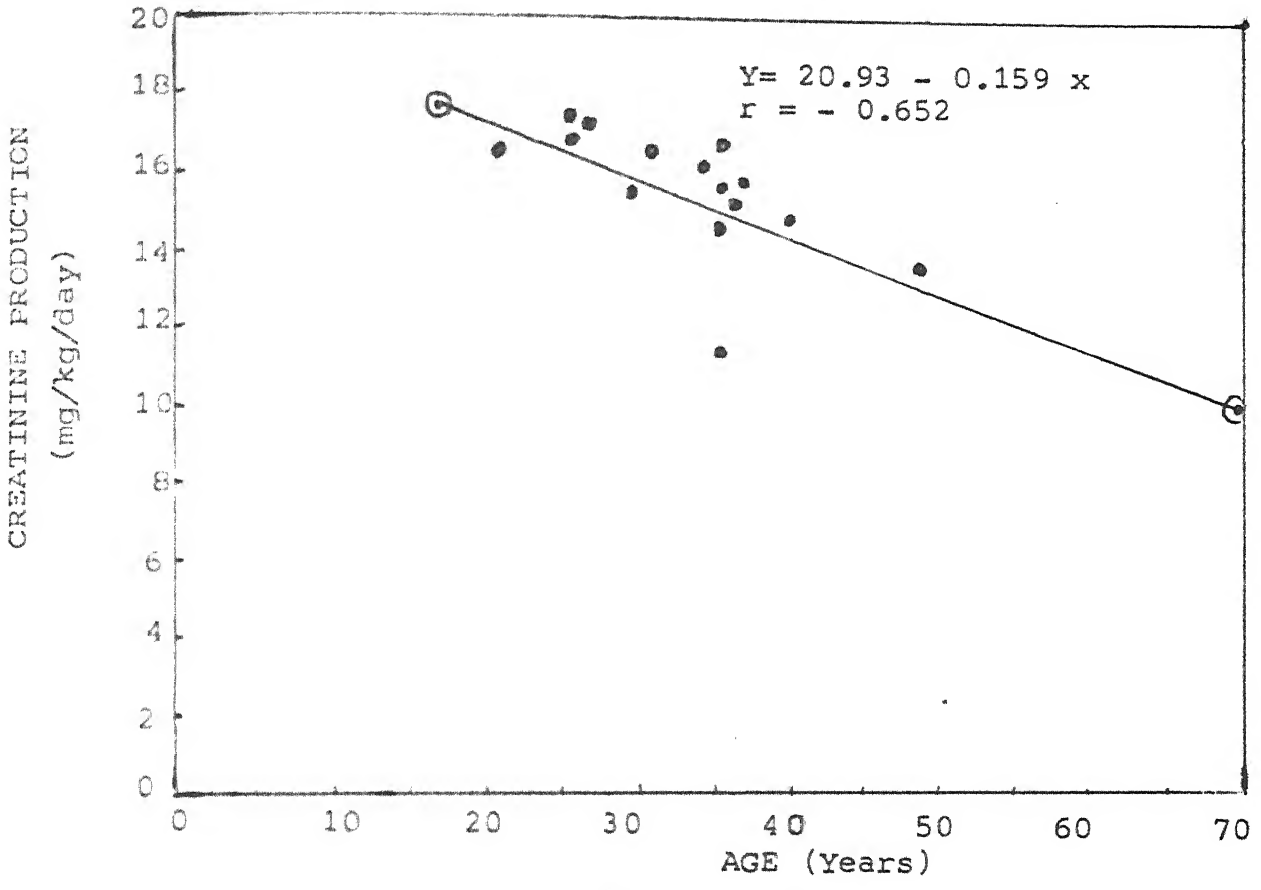
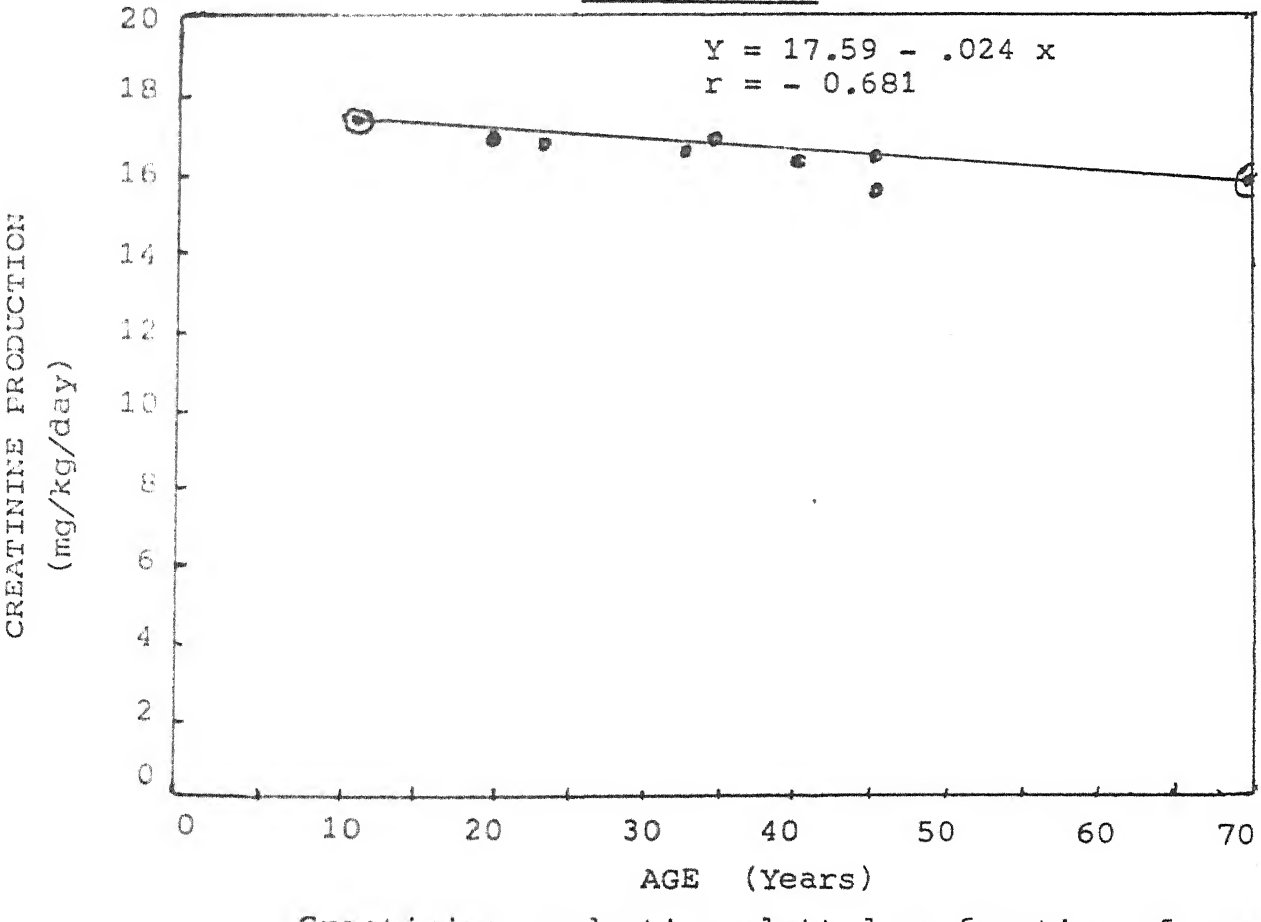


Figure - 4



Creatinine production plotted as function of age. Best-fit line is constructed by regression analysis. Paraplegic (Fig - 3) Quadriplegic (Fig-4).

(ii) Quadriplegics : Figure 4 and table 16 show the creatinine production versus age in quadriplegics.

If the age group 60 years and above were included in the regression analysis. The best fit line was parallel to X-axis. So the age group 60 years and above were excluded from the regression analysis.

In quadriplegics, the age is also correlated significantly ($r = -0.681$, $p < .05$) with creatinine production. The best-fit line shows that creatinine production in quadriplegics also decreases as age increased. Again 46.37 percent ($r = 0.4637$) of the variation in creatinine production may be explained for the by age in quadriplegic patients.

Table - 16

CREATININE PRODUCTION IN QUADRIPLEGIC VERSUS AGE

Sl. No.	Age (yrs)	Sex	Creatinine production (mg/kg/day)
1.	40	M	16.57
2.	35	M	16.90
3.	45	M	16.53
4.	20	M	16.79
5.	23	M	17.00
6.	65	M	16.00
7.	32	M	17.39

B. The creatinine clearance in spinal cord injury patients :

(a) Comparison of measured and predicted creatinine clearance in male.

In table 17, the mean measured creatinine clearance for male patients was 77.03 ± 15.17 ml/min, while the other values for mean urinary creatinine, serum creatinine and urine volume in 24 hour were 43.63 ± 25.71 mg%, 0.71 ± 0.17 mg% and 2350 ± 1059.19 ml respectively. The mean age and weight were recorded as 34.26 ± 8.22 year and 69.8 ± 5.36 kgs respectively.

The mean predicted creatinine clearance from nomogram constructed by Kampmann & Associates was 105 ± 17.33 ml/min.

The predicted creatinine clearance in male was 26.64% exceeded than measured. The difference (df = 26, t = 3.98, $p < .001$) was highly significant.

(b) Comparison of predicted and measured creatinine clearance in female :

The table 18 shows the measured creatinine clearance in female spinal cord injury patients was 50.53 ± 18.57 ml/min at the mean age and weight 42.46 ± 17.96 years and 45 ± 13.16 kgs respectively. While the other values were recorded as urinary creatinine 32.72 ± 16.83 mg. serum creatinine 0.77 ± 0.14 mgh. and 24 hour urine volume 1855 ± 431. 22 ml.

Table - 17

CREATININE CLEARANCE IN MALE SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	WEIGHT KG.	URINARY CR.MG%	SERUM CR MG%	URINARY VOLUME (ML.)	URINE COLLECT. TIME-MIN	CR. CLEARANCE MEASURED	CR. CLEARANCE NOMOGRAM
1	36	49	61.66	0.76	1200.00	1440.00	67.33	90.00
2	38	57	37.86	0.70	2100.00	1440.00	78.87	100.00
3	35	50	28.56	0.80	2000.00	1440.00	49.06	90.00
4	25	48	97.15	0.80	900.00	1440.00	66.79	108.00
5	25	35	27.90	0.60	2150.00	1440.00	69.42	100.00
6	30	55	30.12	0.70	3000.00	1440.00	89.49	120.00
7	40	58	95.55	1.00	900.00	1440.00	59.71	80.00
8	35	48	37.73	0.80	2000.00	1440.00	86.77	120.00
9	40	47	20.50	0.10	3800.00	1440.00	54.09	72.00
10	35	50	28.17	0.40	3000.00	1440.00	96.65	120.00
11	45	50	20.67	0.60	4000.00	1440.00	95.69	120.00
12	20	54	45.34	0.80	2000.00	1440.00	78.11	130.00
13	23	50	77.30	0.80	1100.00	1440.00	73.81	104.00
14	45	52	26.00	0.40	3200.00	1440.00	96.20	110.00
15	32	46	20.00	0.56	4000.00	1440.00	92.58	120.00
MEAN	34.26	49.8	43.63	0.71	2350		77.03	105
+-S.D.	+- 8.22	+- 5.36	+- 25.11	+- 0.17	+-1059.19		+-15.17	+-17.53

Table - 18

CREATININE CLEARANCE IN FEMALE SPINAL CORD INJURY PATIENTS

S.NO.	AGE (YR)	WEIGHT (KG.)	URINARY (CR.MG%)	SERUM (CR MG%)	URINARY VOLUME (ML.)	URINE COLLECT. TIME-MIN	CR. CLEARANCE MEASURED	CR. CLEARANCE NOMOGRAM
1	64	50	19.00	0.72	2000	1440	37.69	70
2	66	40	22.64	0.74	2000	1440	44.92	58
3	65	33	15.50	0.70	2500	1440	38.44	45
4	30	42	18.30	1.00	2800	1440	35.58	62
5	36	44	28.17	0.70	2000	1440	55.89	84
6	20	30	41.25	0.98	1500	1440	44.88	52
7	24	51	30.15	0.70	1900	1440	56.83	100
8	35	80	83.13	0.60	1500	1440	108.11	120
9	35	45	32.63	0.70	1800	1440	58.26	86
10	25	32	45.73	1.00	1200	1440	38.10	54
11	20	30	24.56	1.00	2020	1440	34.45	52
12	67	52	29.78	0.62	1400	1440	48.25	86
13	65	56	34.60	0.66	1500	1440	55.50	72
MEAN	42.46	45	32.72	0.77	1855		50.53	72.38
+-S.D.	+-17.96	+-13.16	+-16.72	+-0.14	+-431.32		+-18.57	+-20.65

From the nomogram the predicted creatinine clearance was 72.38 ± 20.95 ml/min.

In female the predicted value was 30.19% exceeded that of measured. The difference (d.f. = 24, t = 2.84, p <.01) was significant.

(c). Comparison of creatinine clearance in male and female :

(i) Measured creatinine clearance : The table 19 shows the mean measured creatinine clearance in male and female were 77.03 ± 15.17 and 50.53 ± 10.57 ml/min respectively. The difference was (d.f. = 26, t = 4.54, p <.001) highly significant.

Table - 19

COMPARISON OF CREATININE CLEARANCE IN MALE & FEMALE

Creatinine clearance (ml/min)	MALE No.of pts.	MALE Mean Cr.Cl. ± S.D. ml/min	FEMALE No.of pts.	FEMALE Mean Cr.Cl. ± S.D. ml/min
Measured	15	77.03 ± 15.17	13	50.53 ± 10.57
Predicted	15	105.00 ± 17.53	13	72.38 ± 20.65

For measured Cr.Cl. df = 26, t = 4.54, p<.001
For predicted Cr.Cl. df = 26, t = 4.18, p<.001

(11) Predicted Creatinine clearance : The mean predicted creatinine clearance in male and female were 105 ± 17.53 and 72.38 ± 20.65 ml/min respectively. The difference shown in table 17 (df = 26, t = 4.18, p<.001 was highly significant.

(d) Comparison of measured creatinine clearance in Paraplegic and Quadriplegic patients :

Table 20 shows the mean measured creatinine clearance in paraplegic and quadriplegic 60.53 ± 19.13 and 67.74 ± 22.81 ml/min respectively. The difference (df = 26, t = 0.913, p 7.2) was not significant.

Table - 20

COMPARISON OF CREATININE CLEARANCE IN PARAPLEGIC AND QUADRIPLEGIC PATIENTS

No.of patients	Paraplegic Cr.Cl. ± S.D.	No. of patients	Quadriplegic Cr.Cl. ± S.D.
16	60.53 ± 19.13	12	67.74 ± 22.81
df = 26, t = 0.913, p 7.2			

DISCUSSION

DISCUSSION

To assess the renal function, the use of creatinine clearance as a diagnostic tool is not new. Rehberg (1926) first utilized the endogenous creatinine clearance as a measure of glomerular filtration rate. The difficulty of collecting 24 hours urine specimen in hospitalised patients and delays in laboratory analysis have promoted several methods to estimate creatinine clearance that do not require any collection of urine but depend upon easily and quickly measured parameters. The age, height, weight, and serum creatinine have been used commonly to predict creatinine clearance in neurologically intact hospitalised patients by 3 popular methods.

In 1971, Siersbaek-Nielsen suggested the following equations for male and female respectively.

$$\text{Creatinine clearance (male)} = \frac{\text{wt} \times (29.3 - (.203 \times \text{age}))(1.035-(.0337 \times \text{Scr}))}{\text{Scr} \times 14.4}$$

$$\text{Creatinine clearance (female)} = \frac{\text{wt} \times (25.1-(.175 \times \text{age}))\ (1.035-(.0337 \times \text{Cr}))}{\text{Scr} \times 14.4}$$

From these equations the nomogram was also constructed by Siersbaek-Nielsen.

In present study when predicted creatinine clearance of 28 spinal cord injury neurologically abnormal, hospitalised patients by these equations were compared to measured creatinine clearance. The predicted values were high than measured (Fig-1, & table)

Jelliffe RW (1973) proposed the equations

(i) $\underset{(male)}{Cr.cl.} = \frac{28 - 0.8\ (Age - 20)}{Scr}$

(ii) $\underset{(female)}{Cr.cl.} = \frac{28 - 0.8\ (Age - 20) \times .90}{Scr}$

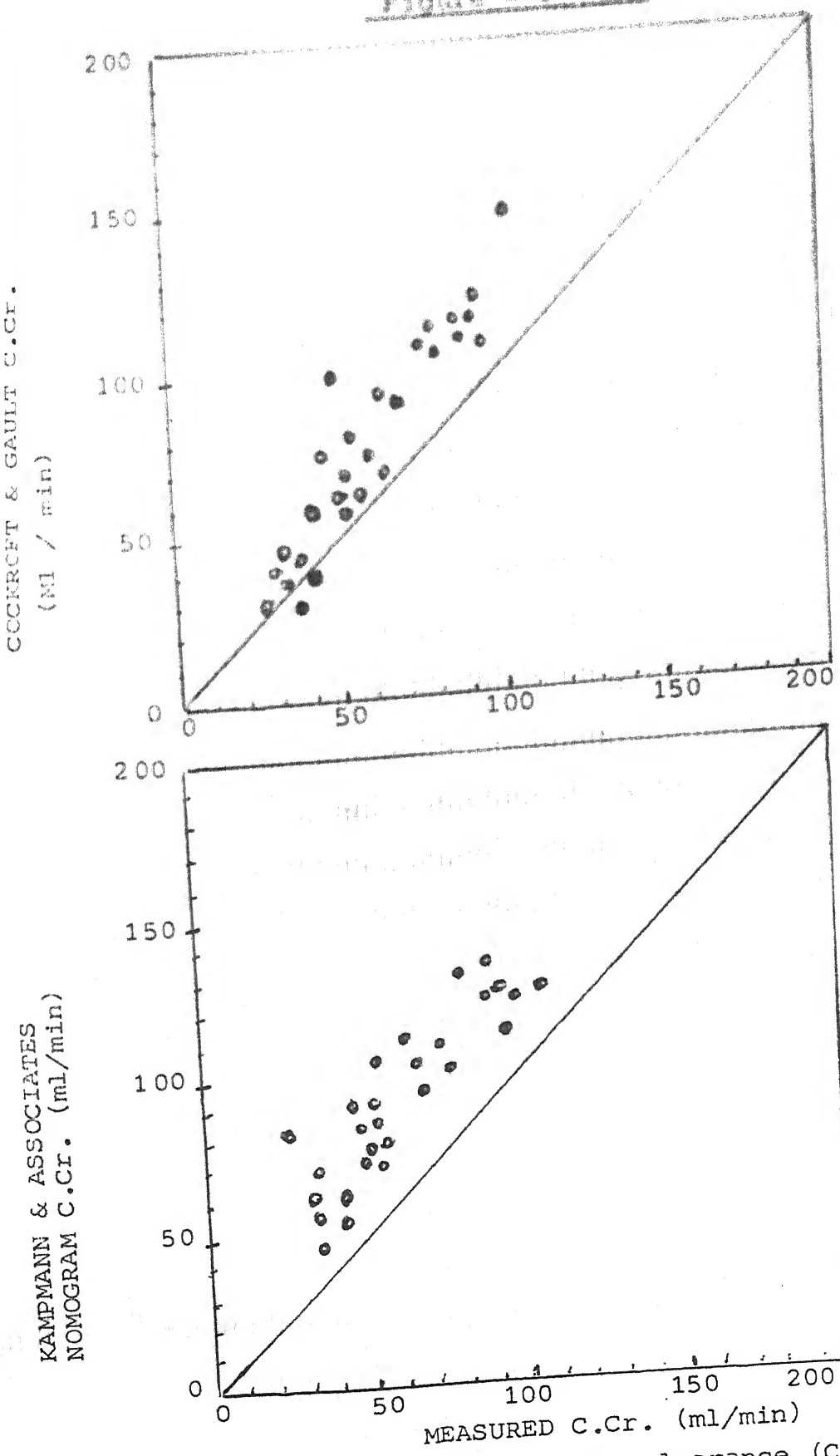
On comparison of predicted creatinine clearance of 28 spinal cord injury patients with measured value, the predicted values were high than measured as shown. (Fig - 2, & table).

Cockcroft and Gault 1976 published the equation and gave the idea to estimate creatinine clearance with the help of age, weight and serum creatinine.

$$\underset{(male)}{\text{Creatinine clearance}} = \frac{wt \times (140 - Age)}{72 \times Scr}$$

A multiplication factor (.85) was applied to predict the creatinine clearance in female. By this equation the predicted values also over estimated than measured (Fig - 3, & table).

Figure - 3 & 4



Predicted versus measured creatinine clearance (C.Cr.). Predicted C.Cr. is plotted as function of actual creatinine clearance as measured in 28 spinal cord injury patients. Black dots indicate predicted C.Cr. that exceeds measured clearance. Conversely, red dots indicate predicted C.Cr. that is less than measured clearance.

In 1974, Kampmann and Associates evaluated a creatinine clearence of 348 hospitalized patients with normal renal functions and 106 patients with abnormal renal functions from the assessment of age, height, weight, serum creatinine and 24 hours urinary creatinine production. They introduced a popular nomogram.

The predicted values of 28 neurologically abnormal patients by Kampmann and Associates's nomogram in this study exceeded that of measured (Fig-4, & table).

The 24 hours urinary creatinine production in Kampmann and Associates' controls exceeded that of spinal cord injury patients in this work by 28 percent in male and 27 percent in female. While age group wise, the study group was compared to control group, the difference in creatinine production in males in between 20-29, 30-39 and 40-49 years were ($p<.001$) highly significant.

In case of female these were also significent except age group (20-29) years.

In that group there were only 3 patients. Therefore, statistically the difference could not be calculated.

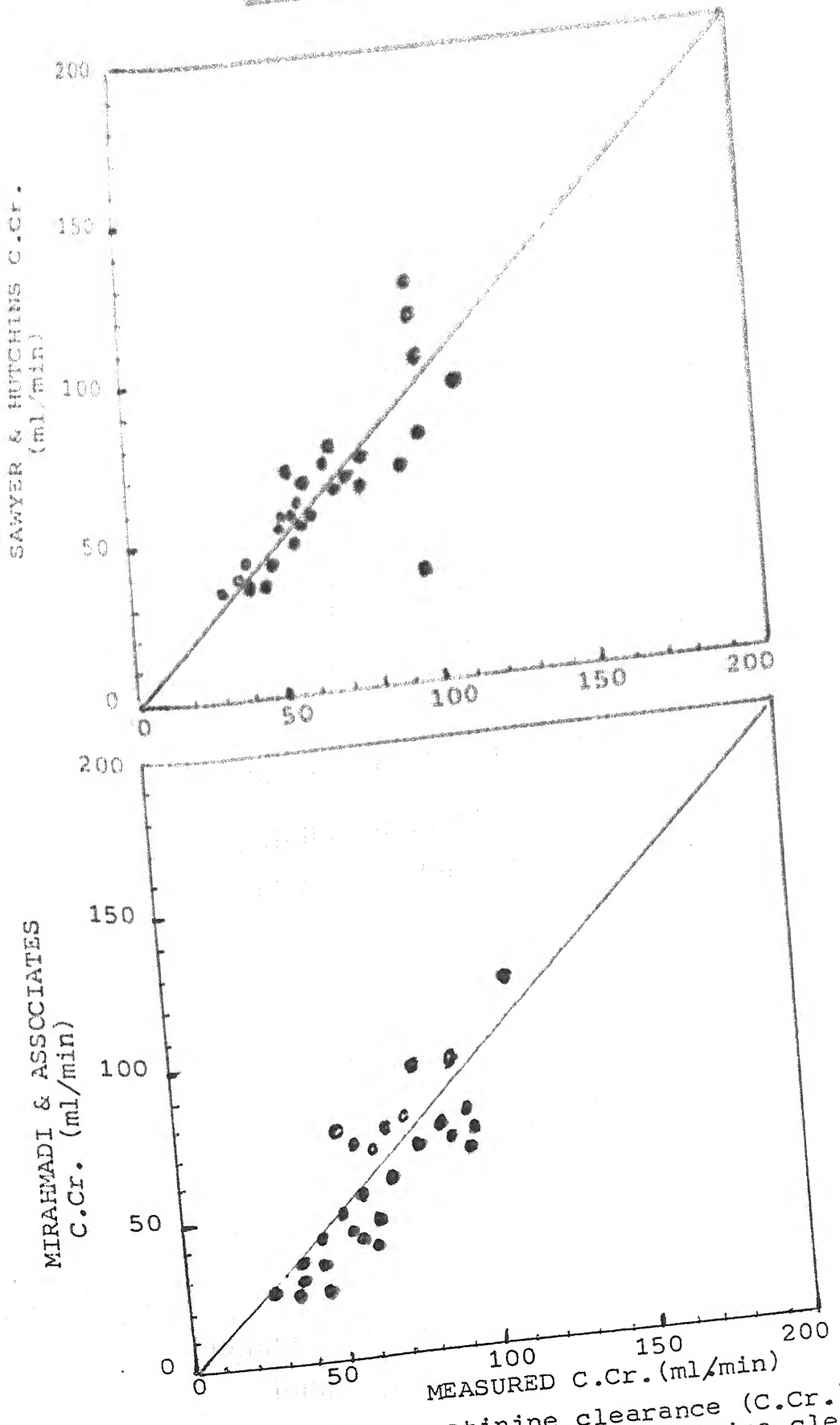
The inadequacy of these equations to predict creatinine clearance in spinal cord injury patients is demonstrated graphically in Fig — 1 & 2, 3 & 4. Therefore, a better means to estimate creatinine clearance in spinal cord injury patients is imperative.

These attempts to predict creatinine clearance more accurately in the spinal cord population have been reported. In 1982 Sawyer & Hutchins examined 5 quadriplegics, 9 paraplegics, 2 stroke patients and 2 patients suffering from multiple sclerosis. When the lean body mass as calculated by Hume (1966) was substituted for actual body weight in the Cockcroft and Gault equation, the creatinine clearance over prediction error was reduced from 31 to 19 percent.

$$\text{Creatinine clearance} = \frac{\text{Lean body mass } (140-\text{Age})}{72 \times \text{Scr}}$$

When predicted values of 20 spinal cord injury patients in this study calculated by Sawyer and Hutchins equation were compared to measured creatinine clearance, the values were close to each other as grephically represented (Fig - 5, 6 table).

In 1983, Mirhamedi & Associates examined the Cockcroft & Gault formula in 36 male quadriplegics and 22 male paraplegics. They applied a correlation factors to correct over estimation of measured creatinine clearance.



Predicted versus measured creatinine clearance (C.Cr.). Predicted C.Cr. is plotted as function of actual creatinine clearance as measured in 28 spinal cord injury patients. Black dots indicate predicted C.Cr. that exceeds measured clearance. Conversely, red dots indicate predicted C.Cr. that is less than measured clearance.

$$\text{Creatinine clearance (male)} = \frac{\text{Wt (140-Age)} \times 0.9}{72 \times \text{Ser}}$$

$$\text{Creatinine clearance (female)} = \frac{\text{Wt (140-Age)} \times 0.8}{72 \times \text{Ser}}$$

When the predicted creatinine clearance by these equation were compared to measured, the 50% predicted values were slightly lower than measured as graphically shown in Fig - 6, 2 table.

In 1986 Mohler and Associates used multi-linear regression analysis to generate prediction equations in 101 spinal cord injury patients (79 male and 22 female, including 63 paraplegics and 38 paraplegics) and proposed.

$$\text{Creatinine production (Quad)} = 16.8 - .04\ X^{*}$$

$$\text{Creatinine production (para)} = 20.6 - (.045 + .14A)^{*}$$

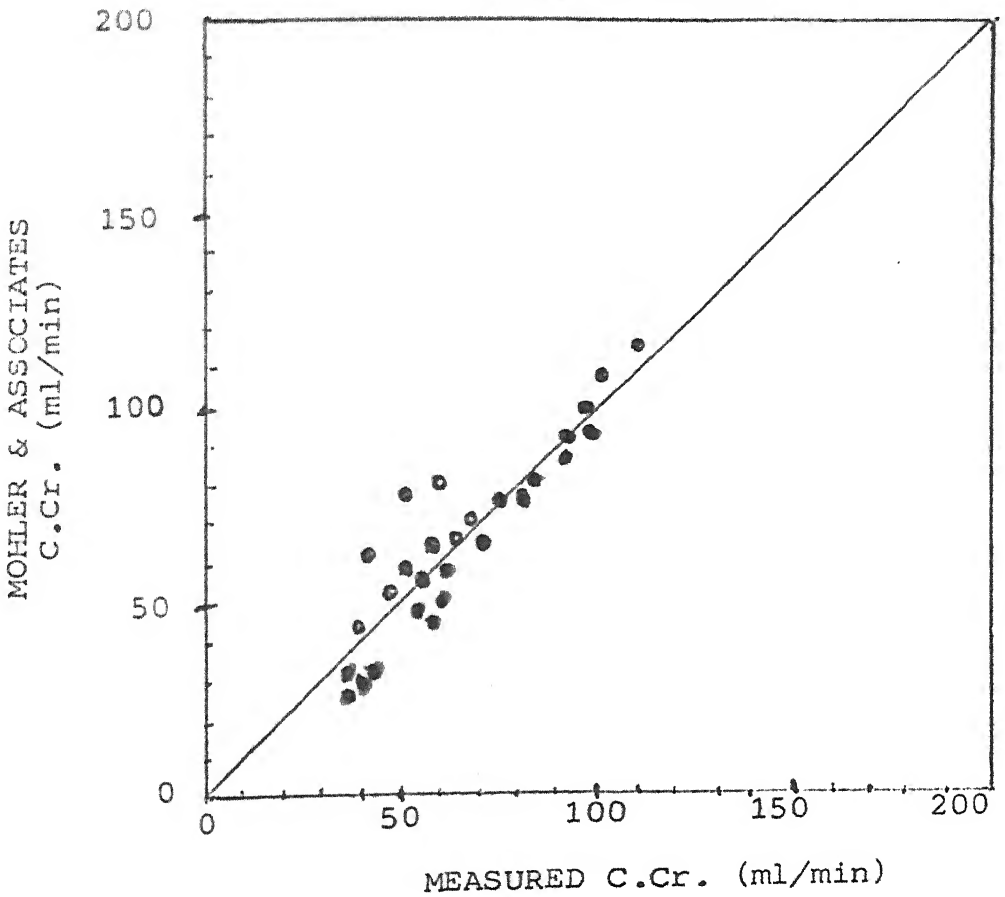
(X = Interval in months, A = Age (years))

$$\text{Creatinine} = \frac{\text{UP} \times \text{Wt} \times 100}{\text{Ser} \times 1440}$$

When the predicted creatinine clearance by Mohler and Associates, equation in 28 spinal cord injury patients were compared to measured, they were near to each other (Fig-7 & table).

The creatinine production mg/kg/day in paraplegics depends upon age and interval since injury. The data in this study is also similar for paraplegics to Mohler & Associates. In quadriplegics the creatinine production

Figure - 7



Predicted versus measured creatinine clearance (C.Cr.). Predicted C.Cr. is plotted as function of actual creatinine clearance as measured in 28 spinal cord injury patients. Black dots indicate predicted C.Cr. that exceeds measured clearance. Conversely, red dots indicate predicted C.Cr. that is less than measured clearance.

depends only upon interval since injury in Mohler and Associates study but in the present work creatinine production depends upon interval since injury and it is inversely perportional to age.

The data of this present work that the urinary creatinine production in spinal cord injury patients are decreased than neurologically intact patients are similar that of Kaji et al (1990) study and other workers. Therefore, the use of equations or nomograms generated from the data of Kampmann and Associates is improper in spinal cord injury patients.

To predict creatinine production in spinal cord injury patients one must examine the effect of the type of injury, the interval since injury and the age and sex of the patients. In this study the creatinine production is not different inherently between quadriplegic and paraplegic, it is also as shown in 1986 by Mohler & Associates, since very begining the relationship of age with creatinine clearance was usual to practice. But it was highlighted in 1976 by Cockcroft and Gault in terms of lean body mass. Mohler and Associates had reported a definite relationship of creatinine production in spinal cord injury patients with age and interval since injury. This study also suggest that the age and interval since injury are important factor in relation to creatinine production.

Table

COMPARISON OF MEASURED & PREDICTED CREATININE CLEARANCES IN SPINAL CORD INJURY PATIENTS

S.NO.	NAME		KAMPMANN & ASSO. NOMOGRAM	MEASURED	MOHLER & ASSO.	JELLIFFE R.W.	COCKCROFT & GAULT	SIERSBAEK NIELSEN	SAWYER & HUTCHINS	MINNAMA MD & ASSO.
1	Smt KALAWATI	62	35.58	29.96	81.00	40.32	45.54	36.36	32.85	
2	Smt RANO	84	55.89	44.25	109.53	59.42	67.86	54.92	49.53	
3	Smt TARA BAI	52	44.66	30.04	90.00	40.81	46.01	38.49	32.64	
4	Smt BHAGWATI	100	56.83	44.72	111.60	60.22	68.76	55.84	48.17	
5	Sri DULICHAND	90	67.33	67.72	112.10	89.34	130.77	73.54	85.49	
6	Sri PRAHLAD	100	78.87	78.03	108.00	115.35	11.80	74.31	82.88	
7	Sri SURESH	90	49.06	59.89	122.85	100.80	97.10	60.59	80.32	
8	Sri LEIKRAM	108	66.79	67.08	107.50	91.84	97.50	65.05	73.47	
9	Sri MAKHAN BAI	120	108.11	115.77	109.70	155.52	178.01	88.64	124.81	
10	Sri TIKARAM	100	69.72	67.32	149.33	93.17	89.50	75.70	72.55	
11	Sri DEEPAK	120	89.40	87.30	156.60	120.07	141.07	73.32	95.09	

Contd...2

12	Sri LALLOO SINGH	70	59.71	58.92	128.00	80.65	83.41	51.79	54.44
13	Sri MANKUNWAR	86	58.26	45.92	110.58	81.68	70.42	56.04	57.29
14	Sri JASODA	54	38.10	30.87	84.60	40.68	48.19	[illegible]	[illegible]
15	Sri PISTA	83	34.45	25.48	88.20	34.64	39.05	[illegible]	[illegible]
16	Sri HARCHRAN	72	55.50	63.63	107.50	87.50	93.21	[illegible]	[illegible]
17	Smt RAMA DEVI	70	37.69	64.36	67.24	38.20	[illegible]	[illegible]	[illegible]
18	Smt KOSALYA	58	44.92	56.05	74.43	37.77	[illegible]	[illegible]	[illegible]
19	Sri DEVLAL	72	54.09	54.57	82.00	85.37	[illegible]	[illegible]	[illegible]
20	Sri CHAITRAM	120	97.85	95.02	143.00	121.52	[illegible]	[illegible]	[illegible]
21	Sri HANUMAN	120	95.69	95.60	130.00	109.95	[illegible]	[illegible]	[illegible]
22	Sri PAPPU	100	76.11	77.48	122.00	112.50	[illegible]	[illegible]	[illegible]
23	Sri RADHEY SHYAM	104	73.81	72.46	199.50	101.59	[illegible]	[illegible]	[illegible]
24	Sri FAIZ KHAN	110	96.20	100.81	130.00	114.35	[illegible]	[illegible]	[illegible]
25	Smt SHANTI	48	38.44	43.63	79.71	39.28	45.42	[illegible]	[illegible]
26	Sri BALDEO SINGH	120	92.58	88.80	147.33	115.00	[illegible]	[illegible]	[illegible]
27	Sri SHYAM BAI	83	48.25	77.17	87.85	88.02	[illegible]	[illegible]	[illegible]
28	Sri RATI	72	85.50	78.47	79.14	70.70	81.84	[illegible]	[illegible]

The difference between quadriplegics and paraplegics can be explained as follows that interval since injury is believed to reflect the degree of muscle wastage, whether caused by reduced dietry intake, disuse atrophy or denervation. The wastage of muscle mass must occur at similar rates in both types of spinal cord injury. The total muscle mass affected would be greater in quadriplegia than paraplegics but the rate of wastage should be similar. Age reflects activity level, which has a direct bearing on muscle mass.

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CONCLUSION

CONCLUSION

The present study was carried out on 28 spinal cord injury patients including 16 males, 12 females, 15 paraplegics and 13 quadriplegics. One hundred and twenty three age and sex matched, neurologically intact, hospitalised individuals including 54 males and 69 females served as controls reported by Kampmann and Associates (1974).

The age (years) height (cm), weight (kg), urinary volume (ml) and urinary & serum creatinine (mg%) were taken in each individual of study group.

The creatinine production in study group was obtained with the help of urine volume, urinary creatinine and weight. And in control group, it was considered as such as reported by Kampmann & Associates (1974).

In study group, the measured creatinine clearance was calculated by serum and urinary creatinine (mg%) and urine volume (ml). The predicted creatinine clearance was estimated by nomograms reported by Kampmann & Associates.

Following conclusions could be drawn from the study :

1. The difference in creatinine production (mg/kg/day) in between study and control group males and females both were statistically significant.

2. The difference in creatinine production (mg/kg/day) in males and females spinal cord injury patients in matching age groups was not significant ($p > .05$).

3. The difference in creatinine production (ml/kg/day) in paraplegics and quadriplegics was also not significant ($p > .05$).

4. The age and interval since injury in spinal cord injury patients were inversely perportional to creatinine production.

5. The difference in predicted and measured creatinine clearance (ml/min) in males was highly significant ($p < .001$). The predicted values exceeded by 26.64% than measured values.

6. The difference in predicted & measured creatinine clearance (ml/min) in females was ($p < .01$) statistically significant and predicted values were exceeded by 30.19% than measured.

7. The difference in measured creatinine clearance in males and females was highly significant ($p < .001$).

8. The difference in predicted creatinine clearance in males and females was highly significant ($p < .001$).

9. The difference in measured creatinine clearance in paraplegics and quadriplegics was not statistically significant (p 7a.3).

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[illegible] CREATININE CLEARANCE IN SPINAL CORD INJURY PATIENTS

Guide : Dr. P.K. Jain, MD, AIIMS

Investigator : Dr. Mahipal Singh

Case No.____

Dated:

Ward/Bed :

U.H.I.D. :

Patient's name

Age / Sex :

Address :

Occupation :

Socio-economic status :

Physical activity : Active/Sedentary

Marital status :

Referred by :

Chief complaints :

1.
2.
3.

HISTORY OF PRESENT ILLNESS

A. Injury

Site Duration

Mode

Other injuries (including head injury) :

B. Paralysis

i. Para/quadriplegia :

ii. Duration of paralysis :

C. Micturition

Haematuria :

Automatic Bladder :

Autonomous bladder :

D.

PAST HISTORY

Hypertension Diabetes mellitus

Tuberculosis Renal colic

Recurrent UTI Swelling over body/feet

FAMILY HISTORY

Tuberculosis :

Hypertension :

Other chronic diseases :

SOCIAL HISTORY

Veg./Non-veg. :

Any intoxication :

HISTORY OF PRESENT ILLNESS

Prior to injury :

During treatment of injury :

CLINICAL EXAMINATION

General Condition	Icterus
Pulse rate	Cyanosis
Temperature	Clubbing
Resp. rate	Hydration
B.P.	Edema
Weight	Lymphadenopathy
Weight	J.V.P.
Pallor	

SYSTEMIC EXAMINATION

RESPIRATORY SYSTEM

CARDIOVASCULAR SYSTEM

ABDOMEN

Tender/nontender :

Liver :

Spleen :

Ascites :

CENTRAL NERVOUS SYSTEM

Appearance and behaviour :
Consciousness :
Orientation in time :
Place & person.
Hallucination :
Delusions :
Memory : Speech : Cranial nerves: